U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

LISTING OF THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (ORIGINAL) A yaw stability system for a vehicle having a plurality of wheels each with a torque control element, said yaw stability system comprising:

a yaw rate sensor measuring a vehicle yaw rate;

a plurality of braking devices each operably associated with one of the torque control elements and configured to exert a braking torque on the control element in response to a control command; and

a control unit communicating with said yaw rate sensor and configured to

identify a desired yaw rate,

determine a yaw rate tracking error based on the difference between the desired yaw rate and the vehicle yaw rate,

determine a yaw condition of the vehicle based on the vehicle yaw rate,

determine a control yaw moment to minimize the yaw rate tracking error,

select one or more of said plurality of braking devices based on the yaw condition, and

communicate a control command to the one or more selected braking devices to induce said control yaw moment.

Page 2 of 14

PAGE 5/17 * RCVD AT 2/2/2006 2:12:06 PM [Eastern Standard Time] * SVR:USPTO-EFXRF-6/29 * DNIS:2738300 * CSID:248 433 7274 * DURATION (mm-ss):05-28

U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

2. (ORIGINAL) The yaw stability system of claim 1 wherein said control unit determines the control yaw moment using a sliding mode control law based on a lumped mass vehicle model.

3. (ORIGINAL) The yaw stability system of claim 2 wherein said control unit determines the control yaw moment (Mz) based on the following equation

$$M_z = I_{zz}\dot{r}_{des} - [a[((C_{FL} + C_{FR})\alpha_F \cos\delta + (\eta_{FL} + \eta_{FR})F_{zF} \sin\delta] - b(C_{RR} + C_{RL})\alpha_R +$$
$$(c*C_{FL} - d*C_{FR})\alpha_F \sin\delta - c(\eta_{FL}F_{zF} \cos\delta + \eta_{RL}F_{zR}) + d(\eta_{PR}F_{zF} \cos\delta + \eta_{RR}F_{zR})] + I_{zz}\eta SAT(\frac{r_{des} - r}{\phi})$$

4. (ORIGINAL) The yaw stability system of claim 1 wherein said braking devices are electromagnetic retarders and wherein said control command is a current command.

5. (ORIGINAL) The yaw stability system of claim 4 wherein said electromagnetic retarders are eddy current machines.

6. (PREVIOUSLY PRESENTED) A yaw stability system for a vehicle having a plurality of wheels each with a torque control element, said yaw stability system comprising:

a yaw rate sensor measuring a vehicle yaw rate;

a plurality of braking devices each operably associated with one of the torque control elements and configured to exert a braking torque on the control element in response to a control command, wherein said braking devices are eddy current machines and wherein said control command is a current command; and

a control unit communicating with said yaw rate sensor and configured to:

U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

identify a desired yaw rate,

determine a yaw rate tracking error based on the difference between the desired yaw rate and the vehicle yaw rate,

determine a yaw condition of the vehicle based on the vehicle yaw rate,

determine a control yaw moment to minimize the yaw rate tracking error,

select one or more of said plurality of braking devices based on the yaw condition, and

communicate a control command to the one or more selected braking devices to induce said control yaw moment,

wherein the control unit estimates braking device saturation torque (T_{est}) based on a quadratic function of rotor speed and excitation current.

7.   (ORIGINAL) The yaw stability system of claim 6 wherein the quadratic function is:

$$T_{est} = f_0(\omega) + f_1(\omega)*i + f_2(\omega)*i^2$$

8.   (ORIGINAL) The yaw stability system of claim 7 wherein the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ are estimated from steady state test data performed for various rotor speeds.

9.   (ORIGINAL) The yaw stability system of claim 8 wherein the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ are defined by

Page 4 of 14

PAGE 7/17 * RCVD AT 2/2/2006 2:12:06 PM [Eastern Standard Time] * SVR:USPTO-EFXRF-6/29 * DNIS:2738300 * CSID:248 433 7274 * DURATION (mm-ss):05-28

U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

$$f_i(\omega) = a_{i0} + a_{i1}\omega + a_{i2}\omega^2$$

and wherein the parameters α_{ij} are estimated through a least square fit based on the steady state test data.

10.   (ORIGINAL) The yaw stability system of claim 9 wherein the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ are estimated by recalculating the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ for each rotor speed based on the estimates of parameters α_{ij} and the parameters α_{ij} are then estimated based on the recalculated coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ through a least square fit based on the steady state test data.

11.   (ORIGINAL) The yaw stability system of claim 4 wherein said control unit is an open loop controller providing a current optimal torque without a current feedback signal from the electromagnetic retarder.

12.   (ORIGINAL) The yaw stability system of claim 4 wherein the control unit is a parametric model control unit.

13.   (ORIGINAL) A method for controlling yaw in a vehicle having front left, front right, rear left, and rear right wheels and a plurality of braking devices each associated with one of the wheels, said method comprising:

determining a vehicle yaw rate;

determining a desired yaw rate;

Page 5 of 14

calculating a yaw rate error based on the difference between the desired yaw rate and the vehicle yaw rate;

determining a control yaw moment using a sliding mode control law based on a lumped mass vehicle model;

selecting one of the braking devices based on a vehicle yaw condition;

determining a control command for the selected braking device based on the control yaw moment; and

communicating the control command to the one or more selected braking devices.

14. (ORIGINAL) The method of claim 13 wherein the step of determining a control command further includes determining a required torque for the selected braking device, said required torque being the torque required from the selected braking device to induce the control yaw moment.

15. (ORIGINAL) The method of claim 14 wherein the plurality of braking devices are eddy current machines, wherein the control command is a current command, and wherein the step of determining the current command further includes determining a saturation torque for the selected braking device based on a quadratic function of control element speed and excitation current.

16. (ORIGINAL) The method of claim 15 wherein the step of determining the current command further includes comparing the saturation torque for the selected braking device to the required torque.

U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

17.   (ORIGINAL) The method of claim 16 wherein the step of determining the current command further includes determining a command current for the selected braking device if the required torque is less than the saturation torque.

18.   (ORIGINAL) The method of claim 16 wherein, if the required torque is greater than the saturation torque, the step of communicating the current command further includes sending a saturation current command to the selected braking device, selecting a second braking device, and sending a second current command to the second braking device to cause the second braking device to exert a torque equal to the difference between the control yaw moment and the saturation torque, and wherein the first and second selected braking devices are on the same lateral side of the vehicle.

19.   (PREVIOUSLY PRESENTED) A method for controlling yaw in a vehicle having front left, front right, rear left, and rear right wheels and a plurality of braking devices each associated with one of the wheels, said method comprising:
determining a vehicle yaw rate;

determining a desired yaw rate;

calculating a yaw rate error based on the difference between the desired yaw rate and the vehicle yaw rate;

determining a control yaw moment using a sliding mode control law based on a lumped mass vehicle model;

selecting one of the braking devices based on a vehicle yaw condition;

determining a control command for the selected braking device based on the control yaw moment, wherein the step of determining a control command further includes determining a required torque for the selected braking device, said required torque being the torque required from the selected braking device to induce the control yaw moment; and

communicating the control command to the one or more selected braking devices,

wherein the plurality of braking devices are eddy current machines, wherein the control command is a current command, wherein the step of determining the current command further includes determining a saturation torque for the selected braking device based on a quadratic function of control element speed and excitation current, and wherein the step of determining the saturation torque (T_{est}) is based on the following equation:

$$T_{est} = f_0(\omega) + f_1(\omega) * i + f_2(\omega) * i^2$$

and wherein the method further includes estimating the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ from steady state test data performed for various rotor speeds.

20.   (ORIGINAL) The method of claim 19 wherein the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ are defined by

$$f_i(\omega) = a_{i0} + a_{i1}\omega + a_{i2}\omega^2$$

and wherein the step of estimating the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ includes estimating parameters αij through a least square fit based on the steady state test data, includes recalculating the coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ for each rotor speed and based on the estimates of parameters αij, and re-estimating the parameters αij based on the recalculated

U.S. Application Serial No. 10/608,906
Attorney Docket: 46107-0037
Response to Office Action of November 2, 2005

coefficient functions $f_0(\omega)$, $f_1(\omega)$, and $f_2(\omega)$ through a least square fit based on the steady state test data.

21. (ORIGINAL) The method of claim 13 wherein the step of determining the control yaw moment includes calculating the control yaw moment based on a derivative of the desired yaw rate.

22. (ORIGINAL) The method of claim 13 wherein the step of determining the control yaw moment includes calculating the control yaw moment based on a saturation function.

23. (ORIGINAL) The method of claim 13 wherein the step of determining the control yaw moment includes calculating the control yaw moment (Mz) based on the following equation:

$$M_z = I_z \dot{r}_{des} - [a[(C_{FL} + C_{FR})\alpha_F \cos\delta + (\eta_{FL} + \eta_{FR})F_{zF}\sin\delta] - b(C_{RR} + C_{RL})\alpha_R +$$
$$(c*C_{FL} - d*C_{FR})\alpha_F \sin\delta - c(\eta_{FL}F_{zF}\cos\delta + \eta_{RL}F_{zR}) + d(\eta_{FR}F_{zF}\cos\delta + \eta_{RR}F_{zR})] + I_z\eta SAT(\frac{r_{des} - r}{\phi})$$

Claims 24-35 (CANCELED)